Decision Rationale
Total Maximum Daily Load for
Linville Creek Bacteria and General Standard Impairments

I. Introduction

The Clean Water Act (CWA) requires a Total Maximum Daily Load (TMDL) be developed for those water bodies identified as impaired by a state where technology-based and other controls will not provide for attainment of water quality standards. A TMDL is a determination of the amount of a pollutant from point, nonpoint, and natural background sources, including a margin of safety (MOS), that may be discharged to a water quality-limited waterbody.

This document will set forth the Environmental Protection Agency's (EPA's) rationale for approving the general standard (benthic) and bacteria TMDLs for the Linville Creek watershed. EPA's rationale is based on the determination that the TMDLs meet the following eight regulatory conditions pursuant to 40 CFR §130.

1) The TMDLs are designed to implement applicable water quality standards.
2) The TMDLs include a total allowable load as well as individual wasteload allocations (WLA) and load allocations (LA).
3) The TMDLs consider the impacts of background pollutant contributions.
4) The TMDLs consider critical environmental conditions.
5) The TMDLs consider seasonal environmental variations.
6) The TMDLs include a MOS.
7) There is reasonable assurance that the TMDLs can be met.
8) The TMDLs have been subject to public participation.

II. Background

The 29,647 acre Linville Creek Watershed is located in Rockingham County. Linville Creek is a tributary to North Fork of the Shenandoah River. Land use in the watershed is dominated by agriculture which comprises 71% of the land. The remaining land is split between forest and rural developments.

In response to Section 303(d) of the CWA, the Virginia Department of Environmental Quality (VADEQ) listed 13.55 miles of Linville Creek on Virginia's 1998 Section 303(d) list as being unable to attain the general standard for aquatic life and primary contact uses. Linville Creek was identifies as watershed VAV-B46R. This decision rationale will address the TMDLs for the aquatic life and primary contact uses.

Linville Creek was listed for violations of Virginia's fecal coliform water quality criteria. Fecal coliform is a bacterium which can be found within the intestinal tract of all warm blooded animals.

Therefore, fecal coliform can be found in the fecal wastes of all warm blooded animals. Fecal coliform in itself is not a pathogenic organism. However, fecal coliform indicates the presence of fecal wastes and the potential for the existence of other pathogenic bacteria. The higher concentrations of fecal coliform indicate the elevated likelihood of increased pathogenic organisms.

EPA has been encouraging the states to use e-coli and enterococci as the indicator species instead of fecal coliform. A better correlation has been drawn between the concentrations of e-coli and enterococci, and the incidence of gastrointestinal illness. The Commonwealth adopted e-coli and enterococci criteria in 2002. Streams will be evaluated via the e-coli and enterococci criteria after 12 samples have been collected using these indicator species. The fecal coliform criteria will be used in the interim and has been modified as well.

As Virginia designates all of its waters for primary contact, all waters must meet the current fecal coliform standard for primary contact. Virginia's standard applies to all streams designated as primary contact for all flows. The fecal coliform criteria was modified in 2002 to require that the fecal coliform concentration not exceed a geometric mean of 200 colony forming units (cfu) per 100 milliliters (ml) of water for 2 or more samples collected over a month nor shall more than 10% of the total samples exceed 400 cfu/100 ml of water. The new e-coli criteria requires a geometric mean concentration of 126 cfu/100ml of water with no sample exceeding 235 cfu/100 ml of water. Unlike the fecal coliform criteria which allows a 10% violation rate the new e-coli criteria requires the concentration of e-coli not exceed 235 cfu/ 100ml of water. The e-coli criteria was found to drive the TMDL allocations because its instantaneous criteria is far more stringent than the other criteria.

Although, the TMDL and criteria require the 235 cfu/ 100 ml of water not to be exceeded waters are not placed on the Section 303(d) list if their violation rate does not exceed 10%. Therefore, the Creek may be deemed as attaining its uses prior to the implementation of all of the TMDL reductions. It is necessary to keep this in mind because of the reductions needed to attain the instantaneous criteria for e-coli. The TMDL calls for a 100% removal of cattle in stream and straight pipes and a 95% reduction in the load from wildlife in-stream. The TMDL also requires between a 96% and 100% reduction in fecal coliform (e-coli) delivered from pervious land segments. The elimination of fecal coliform (e-coli) entering the streams from upland pastures is something that neither the EPA nor the state expect to be able to attain. However, EPA does not expect these reductions to be needed because of the listing protocols discussed above and items associated with the model.

Through the development of these and other similar TMDLs, it was discovered that natural conditions (wildlife contributions to the streams) could cause or contribute to violations of the fecal coliform standard. Thus, many of Virginia's TMDLs have called for some reduction in the amount of wildlife contributions to the impacted streams. EPA believes that a significant reduction in wildlife is not practical and will not be necessary due to the implementation plan discussed below.

A phased implementation plan will be developed for all streams in which the TMDL calls for reductions in wildlife. In the first phase of the implementation, the Commonwealth will begin implementing the reductions (other than wildlife) called for in the TMDL. In Phase 2, which can occur

concurrently to Phase 1, the Commonwealth will consider addressing its standards to accommodate this natural loading condition. The Commonwealth has indicated that during Phase 2, it may develop a Use Attainability Analysis (UAA) for streams with wildlife reductions which are not used for frequent bathing. Depending upon the result of the UAA, it is possible that these streams could be designated as secondary contact for infrequent bathing. The Commonwealth will also investigate incorporating a natural background condition for the bacteriological indicator.

After the completion of Phase 1 of the implementation plan, the Commonwealth will monitor the stream to determine if the wildlife reductions are actually necessary, as the violation level associated with the wildlife loading may be smaller than the percent error of the model or the MOS. In Phase 3, the Commonwealth will investigate the sampling data to determine if further load reductions are needed in order for these waters to attain standards. If the load reductions and/or the new application of standards allow the stream to attain standards, then no additional work is warranted. However, if standards are still not being attained after the implementation of Phases 1 and 2, further work and reductions will be warranted.

Virginia's 305(b)/303(d) guidance states that support of the aquatic life beneficial use is determined by the assessment of conventional pollutants (dissolved oxygen, pH, and temperature); toxic pollutants in the water column, fish tissue, and sediments; and biological evaluation of benthic community data.[1] Therefore, a biological assessment of the benthic community can be used to determine a stream's compliance with the state's general standard for aquatic life use. Virginia uses EPA's Rapid Bioassessment Protocol (RBPII) to determine status of a stream's benthic macroinvertebrate community.[2] This approach evaluates the benthic macroinvertebrate community between a monitoring site and its reference station. Measurements of the benthic community, called metrics, are used to identify differences between monitored and reference stations.[3]

Reference stations are established on streams which are minimally impacted by humans and have a healthy benthic community. Streams that are classified as moderately or severely impaired after an RBPII evaluation are classified as impaired and are placed on the Section 303(d) list of impaired waters. Benthic evaluations typically take place biannually, in the spring and fall. Since the Fall of 1994 Linville Creek has been evaluated as containing a moderately impacted benthic community in 7 of the 10 sampling events.

The RBPII assesses the health of the macroinvertebrate community of a stream. The analysis informs the biologist if the stream's benthic community is impaired. However, it will not inform the

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[1]VADEQ. 1997. 1998 Water Quality Assessment Guidance for 305(b) Water Quality Report and 303(d) TMDL Priority List Report. Richmond, VA.

[2]Tetra Tech 2002. Total Maximum Daily Load (TMDL) Development for Blacks Run and Cooks Creek. Fairfax, Virginia.

[3]Ibid 2

biologist as to what is causing the degradation of the benthic community. Additional analysis is required to determine the pollutants which are causing the impairment. TMDL development requires the identification of impairment causes and the establishment of numeric endpoints that will allow for the attainment of designated uses and water quality criteria.[4] As part of the TMDL development process VADEQ analyzed possible sources of the aquatic life use impairment on Linville Creek.

Two different modeling approaches were used in the development of these TMDLs and will be discussed further below. The TMDLs call for the loads identified in Table 1.

Table 1 - Summarizes the Specific Elements of the TMDLs.

Segment	Parameter	TMDL	WLA	LA	MOS
Linville Creek	Fecal Coliform	2.1E+13(cfu/yr)	1.1E+11(cfu/yr)	2.1E+13(cfu/yr)	Implicit
	Sediment	34,549 (tons/yr)	5.5 (tons/yr)	31,088 (tons/yr)	3,454 (tons/yr)

The United States Fish and Wildlife Service has been provided with copy of this TMDL.

III. Discussion of Regulatory Conditions

EPA finds that Virginia has provided sufficient information to meet all of the eight basic requirements for establishing TMDLs for aquatic life and primary contact use impairments on Linville Creek. EPA is therefore approving these TMDLs. Our approval is outlined according to the regulatory requirements listed below.

1) The TMDL is designed to meet the applicable water quality standards.

Virginia has indicated that excessive levels of fecal coliform due to nonpoint sources (both wet weather and directly deposited nonpoint sources) have caused violations of the water quality criteria and designated uses in the Linville Creek Watershed. The water quality criterion for fecal coliform was a geometric mean 200 cfu/100ml or an instantaneous standard of no more than 1,000 cfu/100ml. Two or more samples over a 30 day period are required for the geometric mean standard. Since the state rarely collected more than one sample over a thirty-day period, most of the samples were measured against the instantaneous standard. The Commonwealth recently changed its bacteriological criteria as indicated above. The new criteria require the fecal coliform concentration not exceed a geometric mean of 200 cfu per 100 ml of water for two or more samples collected over a month nor shall more than 10% of the total samples exceed 400 cfu/100 ml of water. The new e-coli criteria requires a geometric mean of 126 cfu/100ml of water with no sample exceeding 235 cfu/100 ml.

The TMDLs submitted by Virginia are designed to determine the acceptable load of fecal

[4] Ibid 2

coliform which can be delivered to Linville Creek, as demonstrated by the Hydrologic Simulation Program Fortran (HSPF)[5], in order to ensure that the applicable water quality standards are attained and maintained. HSPF is considered an appropriate model to analyze this watershed because of its dynamic ability to simulate both watershed loading and receiving water quality over a wide range of conditions. The HSPF model is being used to determine the fecal coliform deposition rates to the land as well as loadings to the stream from point and other direct deposit sources necessary to support the new fecal coliform and e-coli water quality criterion and primary contact use. The following discussion is intended to describe how controls on the loading of fecal coliform (e-coli) to Linville Creek and its impaired tributaries will ensure that the criterion is attained. The bacteriological TMDL for Linville Creek was developed to attain the new e-coli criteria.

The TMDL analysis allocates the application/deposition of fecal coliform (e-coli) to land based and instream sources. For land based sources, the HSPF model accounts for the buildup and washoff of pollutants from these areas. Buildup (accumulation) refers to all of the complex spectrum of dry-weather processes that deposit or remove (die-off) pollutants between storms.[6] Washoff is the removal of fecal coliform which occurs as a result of runoff associated with storm events. These two processes allow the HSPF model to determine the amount of fecal coliform which is reaching the stream from land based sources. Point sources and wastes deposited directly to the stream were treated as direct deposits. These wastes do not need a transport mechanism to reach the stream. The allocations call for the reduction in fecal coliform wastes delivered by cattle in-stream, wildlife in-stream and straight pipes as well as loads from upland sources.

The TMDL modelers determined the fecal coliform production rates within the watershed. Information and data used in the models was obtained from a wide array of sources, including farm practices in the area, the amount and concentration of farm animals, point sources in the watershed, animal access to the stream, wildlife in the watershed, wildlife fecal production rates, land uses, weather, stream geometry, etc..

Calibration is the process of comparing modeled data to observed data and making appropriate adjustments to model parameters to minimize the error between observed and simulated events.[7] The hydrologic portion of the model was calibrated to the United States Geological Survey gage #01632082 which is located within the watershed. Data was available from the gage from August 1985 through September 2001. The calibration period was from September 1987 through December 1992. This period was selected because it represented the hydrology of the area and included the

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[5]Bicknell, B.R., J.C. Imhoff, J.L. Little, and R.C. Johanson. 1993. Hydrologic Simulation Program-FORTRAN (HSPF): User's Manual for release 10.0. EPA 600/3-84-066. U.S. Environmental Protection Agency, Environmental Research Laboratory, Athens, GA.

[6]CH2MHILL, 2000. Fecal Coliform TMDL Development for Cedar, Hall, Byers, and Hutton Creeks Virginia

[7]Maptech, 2002. Fecal Coliform TMDL Development for Catoctin Creek Impairments, Virginia. April 23, 2002.

critical conditions associated with the watershed. Several parameters including the evapotranspiration rate, recession rates to groundwater and interflow, storage capacity within the subsurface and surface zones, slope, and forest cover were adjusted to insure that the calibration closely represented the observed data. The simulation followed the flow patterns exhibited in the observed data very well. Although, the model under represented summer and winter flows.

In order to insure that the calibration is representing actual conditions properly, the model was transferred to a different time period and run without adjusting the hydrologic parameters. The model for Linville Creek was validated against observed flow data from January 1993 through September 2001. Once again the model followed the flow patterns exhibited in the observed data and slightly under represented the flows.

The model was then adjusted to include the loading of fecal coliform to the stream. The calibration for water quality criteria was conducted from November 1993 through September 2001. The model was calibrated to the eighty-one water quality samples collected by VADEQ during this time. EPA believes that using HSPF to model and allocate fecal coliform will ensure that the primary contact use will be attained and maintained on Linville Creek.

The TMDL for the aquatic life use impairment was developed using a reference watershed approach and the ArcView Generalized Watershed Loading Functions model (AVGWLF). The AVGWLF is a modification to the GWLF model that allows for the incorporation of ArcView. The model provides the ability to simulate runoff, sediment, and nutrient loadings from watersheds given variable source areas (e.g., agricultural, forested, and developed land).[8] AVGWLF is a continuous simulation model that uses daily time steps for weather data and water balance calculations.[9]

As stated earlier, a stressor was not identified for the aquatic use impairment. Therefore, the first matter was to determine what pollutant was causing the impairment to the benthic community. After the review and comparison of stream data to established criteria, it was determined that excess sediment was impacting benthic macroinvertebrate habitat and impairing the streams benthic community. The AVGWLF was used to model the sediment loading to Linville Creek and the reference watershed. The area-weighted sediment loading to the reference watershed was transferred to Linville Creek. It is believed that with a sediment loading similar to that found in the reference watershed, the impaired watershed will be able to attain criteria.

2) The TMDL includes a total allowable load as well as individual WLAs and LAs.

Total Allowable Loads

Virginia indicates that the total allowable loading is the sum of the loads allocated to land based

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[8] Ibid 2

[9] Ibid 2

precipitation driven nonpoint source areas (forest and agricultural land segments), point sources, and the MOS.

Wasteload Allocations

Virginia has stated that there are 35 National Pollutant Discharge Elimination System (NPDES) permitted facilities discharging to Linville Creek with limits for sediment and/or bacteria. Thirty-four of these facilities have effluent limits for bacteria while all thirty-five have sediment limits. Thirty-three of the thirty five facilities are single family treatment units with a total suspended solids (TSS) limit of 30 mg/l and a bacteria limit of 126 cfu/100ml and a design flow of 1,000 gallons per day. The WLA for TSS can be determined by multiplying the concentration by the daily flow by 365. The Virginia Department of Corrections has identical effluent limits to those granted to the single family units however, their daily flow is 30,000 gpd. The last facility is the Broadway water treatment plant. This facility does not discharge bacteria to Linville Creek but has a TSS limit of 30 mg/l and a design flow of 70,000 gpd. Table 2 documents the WLAs for these facilities.

EPA regulations require that an approvable TMDL include individual WLAs for each point source. According to 40 CFR 122.44(d)(1)(vii)(B), "Effluent limits developed to protect a narrative water quality criterion, a numeric water quality criterion, or both, are consistent with assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA pursuant to 40 CFR 130.7." Furthermore, EPA has authority to object to the issuance of any National Pollutant Discharge Elimination System (NPDES) permit that is inconsistent with the WLAs established for that point source.

Table 2 - WLAs for Linville Creek TMDL

Facility	Permit Number	Fecal Coliform (cfu/yr)	E-Coli (cfu/yr)	Sediment (tons/yr)
Virginia DOC	VA0085588	8.29E+10	5.22E+10	1.24
Broadway WTP	VA0079898	N/A	N/A	2.90
Single Family Units	VAG40	2.76E+9	1.73E+9	0.0415

Load Allocations

According to Federal regulations at 40 CFR 130.2(g), LAs are best estimates of the loading, which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading. Wherever possible, natural and nonpoint source loads should be distinguished.

In order to accurately simulate landscape processes and nonpoint source loadings, VADEQ used the GWLF model to represent the impaired watershed for the sediment TMDL. The GWLF

model is a comprehensive modeling system for the simulation of watershed hydrology, point and nonpoint loadings, and receiving water quality. GWLF uses precipitation data for continuous and storm event simulation to determine total loading to the impaired segments from the various land uses within the watershed. Table 3A documents the LA for each land use in the watershed. The channel erosion reductions are expected to occur as a result of the best management practices (BMPs) installed to remove cattle from the stream. These BMPs are necessary to attain the bacteriological TMDL.

Table 3A - Sediment LAs for Linville Creek Watershed

Surface Runoff Source	Existing Load (Tons/yr)	Allocated Load (Tons/yr)	Percent Reduction
Agriculture	28,904.2	26,125.7	9.6
Urban	132.4	132.4	0.0
Channel Erosion	6,407.0	4,831.0	24.6
Forest	144.3	144.3	0.0
Disturbed Forest	158.7	158.7	0.0

In order to accurately simulate landscape processes and nonpoint source loadings, VADEQ used the HSPF model to represent the Linville Creek watershed for the Bacteriological TMDL. The HSPF model is a comprehensive modeling system for the simulation of watershed hydrology, point and nonpoint source loadings, and receiving water quality for conventional pollutants and toxicants[10]. HSPF uses precipitation data for continuous and storm event simulation to determine total bacteria loading to Linville Creek from forest, residential, and agricultural land uses. The total land loading of bacteria is the result of the application of manure and biosolids, direct deposition from cattle, other livestock and wildlife (geese, deer, etc.); the deposition of bacteria from failed septic systems and bacteria production from pets.

In addition, VADEQ recognizes the significant loading of bacteria from cattle in-stream, straight pipes, and wildlife in-stream. These sources are not dependent on a transport mechanism to reach a surface waterbody, and therefore, can impact water quality during low and high flow events. The TMDL model was developed to determine the fecal coliform loading to Linville Creek. The fecal coliform concentration was then placed into a translating equation developed by VADEQ to determine the appropriate e-coli concentration. The TMDL was developed to insure compliance with the e-coli criteria. The fecal coliform loading to the stream from nonpoint sources is quantified in Table 3B.

[10] Supra, footnote 2.

Table 3B - Fecal Coliform LAs for Linville Creek

Surface Runoff Source	Existing Load (Tons/yr)	Allocated Load (Tons/yr)	Percent Reduction
Cropland	4.31E+12	0.17E+12	96
Pasture	54,654E+12	2,186E+12	96
Residential	932E+12	9.3E+12	99
Loafing Lot	2,251E+12	0	100
Forest	12E+12	12E+12	0
Cattle In-Stream	98.5E+12	0	100
Straight Pipes	12E+12	0	100
Wildlife In-Stream	0.7E+12	0.035E+12	95

3) The TMDL considers the impacts of background pollution.

The aquatic life use TMDL inherently accounted for background pollution via the reference watershed approach. The sediment loading to the reference watershed accounted for all sources of sediment and therefore so did the TMDL which was based on this loading. The bacteriological TMDL accounted for background sources as well via the quantification of wildlife loading to the stream and land segments.

4) The TMDL considers critical environmental conditions.

According to the EPA regulation 40 CFR 130.7 (c)(1), TMDLs are required to take into account critical conditions for stream flow, loading, and water quality parameters. The intent of this requirement is to ensure that the water quality of the Linville Creek Watershed is protected during times when it is most vulnerable.

Critical conditions are important because they describe the factors that combine to cause a violation of water quality standards and will help in identifying the actions that may have to be undertaken to meet water quality standards.[11] Critical conditions are a combination of environmental factors (e.g., flow, temperature, etc.), which have an acceptably low frequency of occurrence. In specifying critical conditions in the waterbody, an attempt is made to use a reasonable "worst-case" scenario condition. For example, stream analysis often uses a low-flow (7Q10) design condition because the ability of the waterbody to assimilate pollutants without exhibiting adverse impacts is at a

[11]EPA memorandum regarding EPA Actions to Support High Quality TMDLs from Robert H. Wayland III, Director, Office of Wetlands, Oceans, and Watersheds to the Regional Management Division Directors, August 9, 1999.

minimum. The sources of bacteria for the watershed were a mixture of dry and wet weather driven sources. Therefore, the critical condition for Linville Creek was represented as a typical hydrologic year.

5) The TMDLs consider seasonal environmental variations.

Seasonal variations involve changes in stream flow as a result of hydrologic and climatological patterns. In the continental United States, seasonally high flows normally occur in early spring from snow melt and spring rain, while seasonally low flows typically occur during the warmer summer and early fall drought periods. The HSPF model accounted for seasonal variations via the use of actual weather data for the hydrology. The model also accounted for the seasonal variation in loadings. Bacteria loads changed for many of the sources depending on the time of the year. For example, cattle spent more time in the stream in the summer and animals were confined for longer periods of time in the winter.

6) The TMDLs include a MOS.

This requirement is intended to add a level of safety to the modeling process to account for any uncertainty. The MOS may be implicit, built into the modeling process by using conservative modeling assumptions, or explicit, taken as a percentage of the WLA, LA, or TMDL.

Virginia used an implicit MOS for the bacteria TMDL through the use of conservative modeling assumptions for animal numbers and bacteria production rates. The benthic TMDL reserved 10% of the TMDL loading for an explicit MOS.

7) There is a reasonable assurance that the TMDL can be met.

EPA requires that there be a reasonable assurance that the TMDL can be implemented. The WLA will be implemented through the NPDES permit process. According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source.

Nonpoint source controls to achieve LAs can be implemented through a number of existing programs such as Section 319 of the CWA, commonly referred to as the Nonpoint Source Program. Additionally, Virginia's Unified Watershed Assessment, an element of the Clean Water Action Plan, could provide assistance in implementing this TMDL.

The TMDL in its current form is designed to meet the applicable water quality standards. However, due to the wildlife issue that was previously mentioned, the Commonwealth believes that it may be appropriate to modify its current standards to address the problems associated with wildlife loadings. The Commonwealth is investigating possibly changing the use of these waters or having a

natural condition amendment added to their standards. A change in standard would also help reduce the magnitude of bacteria reduction necessary. Also the Commonwealth will monitor water quality during implementation when it may be discovered that the reductions called for in the TMDL were unnecessary.

8) The TMDLs have been subject to public participation.

To inform the stakeholders of the TMDL process two public meetings were held to discuss the TMDLs. The TMDLs were also opened to public comment twice. The first meeting was held on September 26, 2002 in Linville-Edom Elementary School in Linville, Virginia. Twenty-five people attended this meeting and they were provided with copies of the presentation. The meeting was public noticed on September 9, 2003 and the first public comment period ended on October 25, 2002. The second meeting was noticed on February 24, 2003 and held on March 5, 2003 in Broadway, Virginia. The meeting was attended by approximately 40 people and the comment period closed on April 2, 2003.